FM 24-18

WAR DEPARTMENT FIELD MANUAL

RADIO COMMUNICATION

WAR DEPARTMENT • 28 JANUARY 1944

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This Manual Supersedes Chapter 5, FM 24-5, 19 October 1942

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(For explanation of symbols, see FM 21–6.)

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CHAPTER 1

PURPOSE OF MANUAL AND REFERENCES

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1. PURPOSE AND SCOPE. The purpose of this manual is to furnish basic information about radio communication essential to all personnel using radio as a means of communication. This manual includes a discussion of radio communication fundamentals and the methods and technique involved in the installation and operation of radio communication equipment.

2. REFERENCES. A knowledge of radio procedure (FM 24–6), radio fundamentals (TM 11–455), and International Morse characters (TM 11–459), is assumed. For additional references see—

FM 24–6, Radio Operators Manual, Army Ground Forces. Provides ready reference data required in maintaining field radio communication, it supplements FM 24–10 and TM 11–454.

FM 24–9, Combined United States-British Radiotelephone (R/T) Procedure. Concerns radiotelephone procedure used in combined operations of United States and British forces.

FM 24–10, Combined Radiotelegraph (W/T) Procedure. Concerns radiotelegraph procedure used in combined operations of United States and British forces.

FM 24–11, Combined Operating Signals.

FM 24–12. Army Extract of Combined Operating Signals. An extract (from FM 24–11) of Army Operating Signals for use by radiotelegraph stations of the Army in combined operations with British forces.

FM 24–13, Air Extract of Combined Operating Signals. An extract (from FM 24–11) of Air Operating Signals.

TM 11–454, The Radio Operator. Deals with general radiotelegraph procedure and radio communication security, and contains information concerning operating conditions in the field.

TM 11–455, Radio Fundamentals. Presents an elementary discussion of the basic principles of radio communication systems.

CHAPTER 2

TRANSMISSION AND RECEPTION OF RADIO WAVES

SECTION I

FUNDAMENTALS OF RADIO WAVE PROPAGATION

3. ELEMENTS OF RADIO TRANSMISSION. A pebble dropped into a quiet pool of water will create an action similar to the action of radio waves. The energy of the pebble striking the water will be distributed to all parts of the pool by waves which emanate in circles from the spot where the pebble entered. Radio waves from a vertical antenna act in much the same manner. However, radio waves not only travel along the surface of the ground, but go skyward at an angle with the ground. Other types of antenna may send more of the energy in one direction than in another, but the action and performance of the radio waves will otherwise be the same. The characteristics of a radio wave are as follows:

a. *Speed*, or *velocity*, of radio waves is expressed in meters, and is equal to approximately 300,000,000

meters per second. This is about equal to 186,000 miles per second, or the speed of light.

b. *Wavelength* of radio waves is expressed in meters. The distance the leading part of one wave has traveled when the next wave starts is the wavelength. As shown in figure 1, this is the same as the distance between the crest of the first wave and the crest of the next wave.

c. *Frequency* of radio waves is expressed in kilocycles (kc) or in megacycles (mc), and is the actual number of waves transmitted or received per second. A kilocycle is equal to 1,000 cycles, and a megacycle is equal to 1,000,000 cycles.

d. The important relationship between speed, frequency, and wavelength is shown by the formula:

$$V = f\lambda$$

where V (velocity) = 300,000,000 meters per second
f is the frequency expressed in cycles per second
(Greek letter "lambda") is the wavelength in meters.

This relation is graphically expressed in figure 1. Since the velocity of a radio wave is constant, regardless of its frequency, the wavelength can be found by dividing the velocity by the frequency of the wave.

$$\lambda (\text{wavelength in meters}) = \frac{300{,}000{,}000}{f \text{ (frequency in cycles per second)}}$$

When the wavelength is known and it is desired to find the frequency, the velocity is divided by the wavelength.

$$f \text{ (frequency in cycles per second,} = \frac{300,000,000}{\text{(Wavelength in meters)}}$$

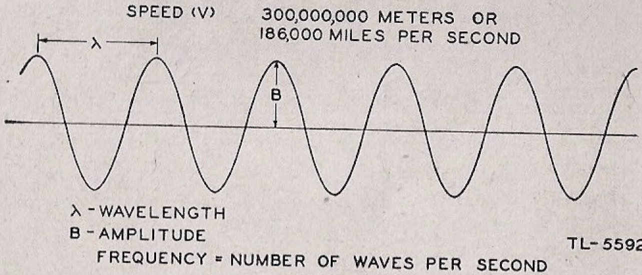


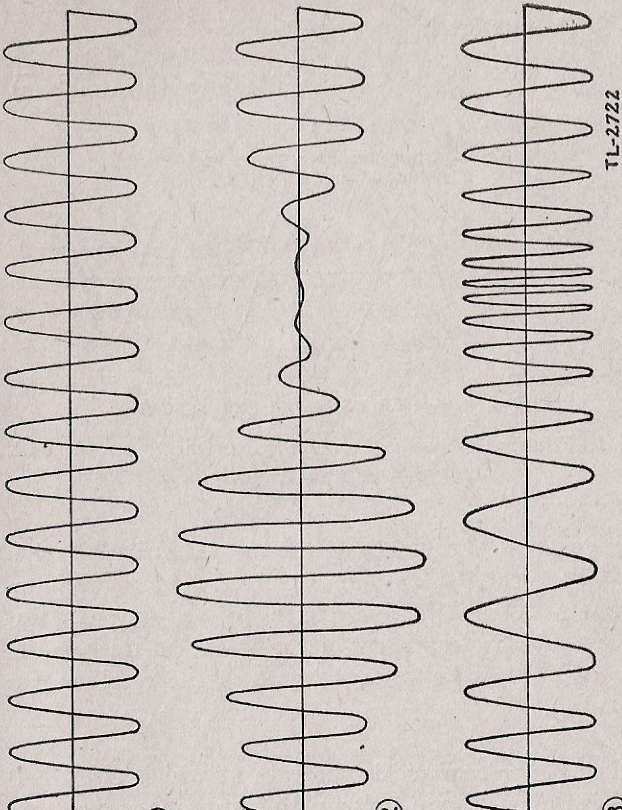
Figure 1. Relations between frequency, wavelength, speed, and amplitude of a radio wave.

e. *Amplitude*, or strength, is the intensity of the wave at a receiving antenna, expressed in microvolts per meter. The "effective length" of the antenna (in meters) times the intensity of the wave (in microvolts per meter) gives the voltage input to the receiver (in microvolts).

f. The *power radiated* is the rate at which electrical energy is radiated by a transmitting antenna, expressed in watts.

4. MODULATED AND UNMODULATED RADIO WAVES. a. A radio wave of unchanging amplitude and unchanging frequency is said to be *unmodulated*.

Such a wave is shown in figure 2①, and is commonly called a *carrier*.



① Unmodulated radio wave. ② Amplitude-modulated radio wave.
③ Frequency-modulated radio wave.

Figure 2. Types of radio waves.

b. A radio wave the amplitude or frequency of which is varied in accordance with a signal is said to be *modulated.* A radio wave the frequency of which remains unchanged, but the amplitude of which is made to vary in accordance with a signal, is said to be *amplitude-modulated* (fig. 2②). A radio wave the amplitude of which remains unchanged, but the frequency of which is varied in accordance with a signal, is said to be *frequency-modulated* (fig. 2③).

5. CONTINUOUS-WAVE SIGNALS. Radiotelegraph, or continuous wave (c-w), signals are produced by *keying* an unmodulated carrier. An audible note is obtained at the receiver by mixing the incoming r. f. signal with a locally generated signal. The local signal is generated in the receiver by a device known as a *beat-frequency oscillator.* The audible note from the receiver follows the keying of the transmitter, and intelligence is conveyed from the transmitter to the receiver by means of International Morse Code. One of the advantages of radiotelegraph, or c-w, signals is that for a given power, greater range and sharper tuning can be obtained than with any other type of radio signal.

6. VOICE-MODULATED AND TONE-MODULATED SIGNALS. These signals are made by combining audio signals, from either a tone source or voice, with r. f. waves within the transmitter. The resultant transmitted signal is either amplitude-modulated or frequency-modulated (par. 4). In voice modulation, many audio frequencies corresponding to the voice sounds are present. Only one audio frequency is present in tone modulation. At the receiver, the audio

component of the incoming wave is reproduced through a headset or loudspeaker. It is possible to receive tone-modulated radiotelegraph signals with a receiver not equipped with a beat-frequency oscillator.

7. COMPARISON OF F-M AND A-M SYSTEMS.

a. Carrier frequency. F-m systems require channel widths of from 50 to 150 kilocycles for each station, and very high carrier operating frequencies are required to accommodate a reasonable number of transmitting stations. A-m systems operate on narrower channels and can be used with any practicable carrier frequency.

b. Equipment location. F-m transmission and reception is confined to approximate *line-of-sight* paths, because of the characteristics of high-frequency (h-f) radio waves (pars. 9 to 12). Transmitters and receivers operating with amplitude modulation are less restricted in location.

c. Interference. In f-m systems, a received signal of approximately twice the strength of other signals will completely block out the other signals. In some instances, this strong signal may be an unwanted signal from an adjacent f-m transmitter and the desired signal cannot be heard. It may occasionally be possible to shift the receiver antenna to a position that will bring in the desired signal to the exclusion of all other signals. In a-m systems, weaker signals are not blocked out and may interfere with the reception of a stronger signal This interference may be so great as to prohibit the copying of messages except by a very experienced operator. (For methods of overcoming interference see pars. 32 to 34, incl.)

8. DESIGNATION OF R-F BANDS. The radio frequencies extend from about 20 kilocycles to over 30,000 megacycles. Since different groups of frequencies within this broad range produce different effects in transmission, the radio frequencies are divided into groups, or *bands*. The bands used for military purposes are as follows:

Designation of band	Authorized abbreviation	Frequency range
Very-low-frequency	v-l-f	Below 30 kc.
Low-frequency	l-f	30 kc to 300 kc.
Medium-frequency	m-f	300 kc to 3000 kc.
High-frequency	h-f	3000 kc to 30 mc.
Very-high-frequency	v-h-f	30 mc to 300 mc.
Ultra-high-frequency	u-h-f	300 mc to 3000 mc.
Super-high-frequency	s-h-f	Above 3000 mc.

SECTION II

GROUND WAVE AND SKY WAVE

9. RADIO WAVE COMPONENTS. The wave radiated from a transmitting antenna may be regarded as consisting of two parts. One part of the radiated energy travels along the surface of the earth and is called the *ground wave*. The remaining portion is radiated upward into space at an angle with the ground and is called the *sky wave*. The sky wave does not come under the influence of the ground to any great extent.

10. GROUND WAVE. The ground-wave component of the radiated wave rapidly loses strength because of spreading and absorption by the ground. The rapidity

of absorption is variable, being dependent upon the type of earth surface, vegetation, and man-made structures. No general statement can be made regarding the distance that will be covered by the ground wave for a given power or frequency. A radio wave of given characteristics may extend several times as far across salt water as across land. As a rule, more moisture in the ground will result in less absorption, and the distance covered with a given power output will increase. The loss in signal strength will generally be more rapid at higher frequencies. At frequencies above 20 megacycles, the ground wave is more or less limited to the line-of-sight, or horizon, distance. Most field radio communication is dependent upon the ground wave.

11. SKY WAVE. a. The energy radiated upward by an antenna travels skyward until it strikes a heavily ionized (charged) region known as the *ionosphere* (formerly called the Kennelly-Heaviside layer). The distance of this layer varies from about 70 to 250 miles above the earth. The ionosphere itself varies in depth and degree of ionization, depending upon the time of day, the season, and solar activity. There are also changes from month to month, and from year to year. The paths of r. f. waves passing through the ionosphere are refracted by the action of the ionization, or electrical charge. Some of the sky waves penetrate the ionosphere and are lost, but more often they are refracted in their paths and reflected back to earth at distant points. Whether or not the waves penetrate the ionosphere or return to earth depends upon the frequency of transmission, the time of day, the time of year, and several other variable factors. Long-range

radio communication is accomplished by means of the sky wave.

b. In general, the distance between the transmitting antenna and the point at which the sky wave first returns to earth is greater at higher radio frequencies. For a given frequency, this distance is also greater at night than in the daytime, and greater in winter than in summer.

c. Sky waves may strike the earth, be reflected back into the ionosphere, and be again reflected back to earth at a more distant point. This additional reflection between earth and ionosphere is accompanied by an attenuation of the radio wave, so that after a number of such reflections (depending upon the original power of the transmitter) the signal will usually be too weak for the most sensitive receiver.

d. Above a certain high frequency and for a given distance (the exact figure depending upon all the factors mentioned previously), the sky wave is not refracted enough to cause it to return to earth; it therefore pierces the ionosphere and is lost in space. At such very high frequencies, all radio communication is accomplished by means of the ground wave, or on approximate line-of-sight radiation, which is regarded as part of the ground wave.

e. Below a certain frequency and for a given distance (the exact figure depending upon the factors mentioned above and also on radiated power, antenna characteristics, atmospherics, and man-made interference), the wave is absorbed to such an extent that it is too weak to be used when it returns to earth. Below this frequency, called the *lowest useful high frequency*, communication is possible only by means of the ground wave.

f. There is thus an upper and a lower limit to the frequencies which are useful for sky-wave communication over a given distance. Similarly, there is an upper and a lower limit to the distances over which sky-wave communication can be realized on a given frequency. The lower limit is called the *skip distance* (par. 12), and corresponds to the maximum usable frequency limitation; the upper limit is called the *distance range*, and corresponds to the lowest useful frequency limitation.

12. USE OF GROUND AND SKY WAVES. A graphic representation of ground and sky waves is shown in figure 3. Assume that a radio transmitter *A* is operating on any given frequency. Communication with a receiver located at point *B* will be accomplished by means of the ground wave. A receiver at point *C* will be reached with the sky wave. However, consider a point *X*, between points *B* and *C*. The ground wave does not extend to this point, and the first sky wave to return to the earth is beyond this point (fig. 3). The

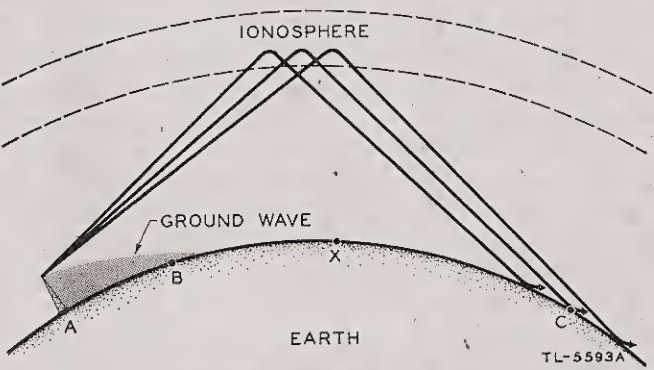


Figure 3. Ground and sky waves.

distance from the transmitter to the point where the first sky wave returns to earth is the skip distance. In order for the transmitter to contact a receiving set at point *X*, it is necessary to select either a frequency that will be returned to earth at this point, or one the ground wave of which will extend to point *X*. If the ground wave were just short of reaching the desired receiving point, it might be possible to reach it on the same frequency by adding power to the transmitter.

SECTION III

ANTENNAS

13. FIELD EXPEDIENTS. The antenna supplied with a field radio set is designed to put out a strong ground wave in all directions over the range normally required. The antenna is compact and easily installed, and for all normal operations no attempt should be made to improve upon it. Under certain conditions, however, an increase in the normal range of the set may be necessary. This can be accomplished by using either of two easily constructed antennas. Wire for constructing either of these improvised antennas should be of copper, size No. 12 or larger. If this, or other copper wire, is not available, a satisfactory antenna can be constructed with ordinary field wire.

14. SINGLE-WIRE-FED HERTZ ANTENNA. a. This antenna receives its name from its transmission line or feeder. It is also known as the "off-center-fed" Hertz antenna, because the feeder is attached at a point off center. In constructing this antenna, it is necessary

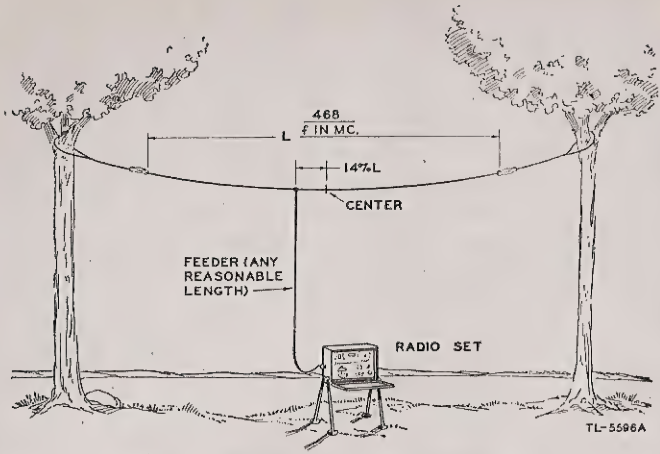


Figure 4. Single-wire-fed Hertz antenna.

first to determine the length of the antenna proper, or *flat top*. This can be done by use of the formula:

$$L=\frac{468}{f}$$

where L is the length in feet of a half-wave antenna
f is the frequency in megacycles.

Example: Determine the length of a Hertz antenna for operation at a frequency of 3920 kilocycles.

3920 kilocycles=3.92 megacycles.

$$L=\frac{468}{f}$$

$$=\frac{468}{3.92}=119.38$$

L=about 119 feet 5 inches, the length of the flat-top antenna.

b. Having determined the length of the flat top, add an allowance for fastening insulators and then cut the wire. From either end, measure a distance equal to 36 percent of the total antenna length. At this point, remove any insulation and connect the feeder wire securely to the antenna wire. The feeder is a single wire long enough to reach from the transmitter to the antenna. The feeder connection to the antenna should be soldered whenever possible.

c. The antenna is now suspended as high above the ground and as much in the clear as conditions permit (fig. 4). Orient the antenna in such a way that the length of the flat top is perpendicular (broadside) to the direction of the station to be contacted. The insulators used for holding the antenna should be ceramic or glass. Hard, dry wood may be substituted if ceramic or glass insulators are not available.

d. The following table shows the antenna length and the point of attachment of the single-wire feeder for most of the commonly used ratio frequencies:

APPROXIMATE LENGTH OF SINGLE-WIRE-FED HERTZ ANTENNA FOR VARIOUS FREQUENCIES

Frequency (kc)	Antenna length (ft)	Feeder distance from one end (ft)	Frequency (kc)	Antenna length (ft)	Feeder distance from one end (ft)
1500	312	112. 3	2100	222	79. 9
1550	302	108. 7	2150	218	78. 5
1600	292	105. 1	2200	213	76. 7
1650	284	102. 2	2250	208	74. 9
1700	275	99. 0	2300	203	73. 1
1750	267	96. 1	2350	199	71. 6
1800	260	93. 6	2400	195	70. 2
1850	253	91. 1	2450	191	68. 8
1900	246	88. 6	2500	187	67. 3
1950	240	86. 4	2550	183	65. 9
2000	234	84. 2	2600	180	64. 8
2050	228	82. 0	2650	177	63. 7

APPROXIMATE LENGTH OF SINGLE-WIRE-FED HERTZ ANTENNA FOR VARIOUS FREQUENCIES—Continued

Frequency (kc)	Antenna length (ft)	Feeder distance from one end (ft)	Frequency (kc)	Antenna length (ft)	Feeder distance from one end (ft)
2700	173	62. 3	4800	97. 5	35. 1
2750	170	61. 2	4850	96. 5	34. 7
2800	167	60. 1	4900	95. 5	34. 4
2850	164	59. 0	4950	94. 5	34. 0
2900	161	58. 0	5000	93. 5	33. 6
2950	158	56. 9	5050	92. 5	33. 3
3000	156	56. 1	5100	92	33. 1
3050	153	55. 1	5150	91	32. 8
3100	151	54. 3	5200	90	32. 4
3150	148	53. 3	5250	89	32. 0
3200	146	52. 5	5300	88	31. 7
3250	144	51. 8	5350	87. 5	31. 5
3300	142	51. 1	5400	86. 5	31. 2
3350	140	50. 4	5450	86	30. 9
3400	138	49. 5	5500	85	30. 6
3450	136	48. 9	5550	84	30. 3
3500	134	48. 2	5600	83. 5	30. 0
3550	132	47. 5	5650	83	29. 8
3600	130	46. 8	5700	82	29. 5
3650	128	46. 1	5750	81. 4	29. 3
3700	126	45. 4	5800	81	29. 1
3750	125	45. 0	5850	80	28. 8
3800	123	44. 3	5900	79. 4	28. 6
3850	122	43. 9	5950	78. 8	28. 4
3900	120	43. 2	6000	78. 0	28. 1
3950	118	42. 5	6050	77. 5	27. 9
4000	117	42. 1	6100	76. 8	27. 7
4050	115	41. 4	6150	76. 2	27. 4
4100	114	41. 0	6200	75. 5	27. 2
4150	113	40. 6	6250	75. 0	27. 0
4200	111	40. 0	6300	74. 4	26. 8
4250	110	39. 6	6350	73. 8	26. 6
4300	109	39. 2	6400	73. 2	26. 4
4350	108	38. 8	6450	72. 6	26. 1
4400	106	38. 2	6500	72. 0	25. 9
4450	105	37. 8	6550	71. 5	25. 7
4500	104	37. 4	6600	71. 0	25. 5
4550	103	37. 0	6650	70. 5	25. 4
4600	102	36. 7	6700	70. 0	25. 2
4650	101	36. 4	6750	69. 5	25. 0
4700	100	36. 0	6800	69. 0	24. 8
4750	98. 5	35. 5	6850	68. 5	24. 6

APPROXIMATE LENGTH OF SINGLE-WIRE-FED HERTZ ANTENNA FOR VARIOUS FREQUENCIES—Continued

Frequency (kc)	Antenna length (ft)	Feeder distance from one end (ft)	Frequency (kc)	Antenna length (ft)	Feeder distance from one end (ft)
6900	68. 0	24. 4	8500	55. 0	19. 8
6950	67. 4	24. 3	8600	54. 5	19. 6
7000	67. 0	24. 1	8700	53. 8	19. 4
7050	66. 5	24. 0	8800	53. 2	19. 2
7100	66. 0	23. 8	8900	52. 6	18. 9
7150	65. 5	23. 6	9000	52. 0	18. 7
7200	65. 0	23. 4	9100	51. 5	18. 5
7250	64. 5	23. 2	9200	50. 9	18. 3
7300	64. 2	23. 1	9300	50. 4	18. 1
7350	63. 7	22. 9	9400	49. 8	17. 9
7400	63. 4	22. 8	9500	49. 4	17. 8
7450	63. 0	22. 7	9600	48. 8	17. 7
7500	62. 5	22. 5	9700	48. 4	17. 5
7550	62. 0	22. 3	9800	47. 8	17. 3
7600	61. 6	22. 2	9900	47. 4	17. 1
7650	61. 3	22. 0	10000	46. 8	16. 9
7700	61. 0	21. 9	10200	45. 8	16. 5
7750	60. 5	21. 8	10400	45. 0	16. 2
7800	60. 0	21. 7	10600	44. 1	15. 9
7850	59. 7	21. 5	10800	43. 3	15. 6
7900	59. 3	21. 4	11000	42. 5	15. 3
8000	58. 5	21. 1	11200	41. 8	15. 0
8100	57. 8	20. 8	11400	41. 0	14. 8
8200	57. 1	20. 6	11600	40. 3	14. 5
8300	56. 4	20. 3	11800	39. 6	14. 2
8400	55. 7	20. 1	12000	39. 0	14. 0

15. LONG-WIRE ANTENNA. This type of antenna is more directional than the Hertz antenna (par. 14). The long-wire antenna is a single wire equal in length to two or more half-wave antennas for a given frequency. To construct a long-wire antenna, measure off a section of wire two or more half-wavelengths long ($L=\frac{468}{f}$ for one half-wavelength). This wire is then suspended between two supports as high as possible,

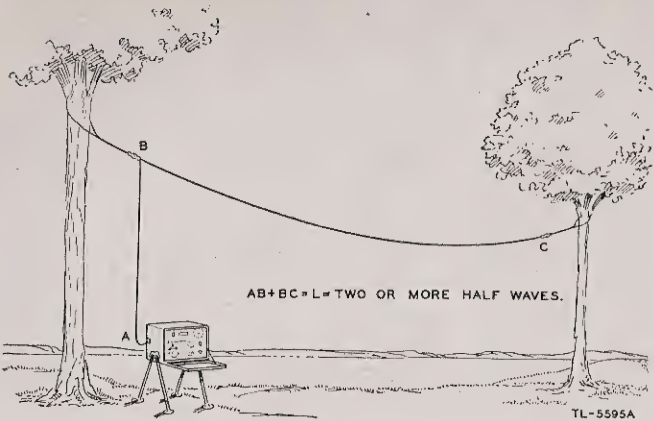


Figure 5. Typical long-wire antenna.

leaving enough wire at one end to reach and connect to the transmitter antenna tuning unit (fig. 5). This type

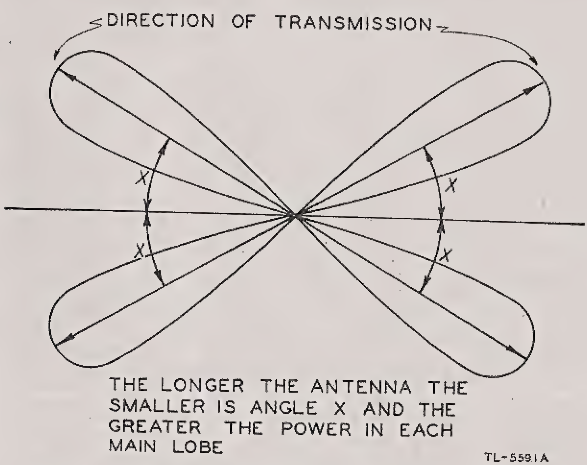


Figure 6. Radiation pattern for a long-wire antenna.

of antenna should be constructed so that it points in the general direction of the stations to be contacted. If the station is not contacted after a reasonable trial, the antenna should be shifted so that it points in a slightly different direction, and another attempt made. A long-wire antenna radiates more energy in one direction than in another, and the pattern of radiation is diagrammatically shown in figure 6. The directional effect of long-wire antennas increases with added half-wavelengths.

SECTION IV

FACTORS CONTROLLING RANGE OF COMMUNICATION

16. FACTORS INVOLVED AT TRANSMITTER.

a. Frequency. The ground wave is used for most field radio communication. When the transmitter is operating in the low-frequency band (30 to 300 kilocycles), the range of the ground wave may be as great as several hundred miles. This range becomes correspondingly shorter as the operating frequency of the transmitter is increased through the medium-frequency band (300 to 3000 kilocycles) to the high-frequency band (3000 kilocycles to 30 megacycles). When the transmitter is operating at frequencies above 30 megacycles, the range of the ground wave is limited to the distance to the horizon, called the line-of-sight radiation. Certain large or fixed high-powered transmitters operating in the high-frequency band make use of sky-wave radiation to establish fairly reliable communication over distances sometimes as great as 10,000 miles when necessary.

b. Power. The range of the transmitted signal will

be somewhat proportional to the amount of power radiated by the antenna. That is, an increase in power will result in some increase in range, and a power decrease will decrease the range. This relation is not strictly proportional, however, and varies with frequency and with the operating characteristics of various types of radio sets. Under normal operating conditions the transmitter should feed only enough power into the radiating antenna to establish communication with the receiving station. Transmitting a signal more powerful than necessary is a breach of signal security, since it divulges the location of the transmitter to a much wider area of possible enemy direction finders.

c. Antenna. For maximum transfer of energy, the radiating antenna must be cut to the proper length for the frequency of operation, and must be correctly matched and tuned to the output tank circuit of the transmitter. The condition of the local terrain plays an important part in determining the radiation pattern, and thus affects the directivity of the antenna and the possible range of the set in the desired direction. If possible, several variations in the physical position of the antenna should be attempted to determine an optimum operating position radiating the most energy in the desired direction.

d. Capabilities of operator. The skill and technical capabilities of the transmitter operator play an important part in obtaining the maximum possible range. The transmitter, coupling output, and antenna feeder circuits must be correctly tuned to obtain maximum power output. When it is necessary to erect a radiating antenna, it must be properly constructed with regard to both electrical characteristics and condition of the local terrain.

17. FACTORS INVOLVED IN PATH OF TRANSMISSION BETWEEN TRANSMITTING AND RECEIVING STATIONS. a. Conductivity of intervening terrain. The type of terrain existing between two field radio sets has an effect on the ground wave, known as *ground conductivity*. Flat prairie country usually has a high value of conductivity, and there is little absorption of the ground wave by the earth. Large surfaces of water also have high conductivity. Mountainous, rugged, and broken country usually has a low value of ground conductivity, and in the immediate region of large mineral deposits and in deep ravines and valleys there may be *no* radiation from the transmitter due to complete absorption of the ground wave by the earth.

b. Height of intervening terrain. Large terrain obstructions between the transmitting and receiving stations have an effect similar to that discussed in **a** above.

c. Distance between stations. Radio transmitters having a limited range must work with receivers located within this range. Large transmitters radiating both ground and sky waves may be able to reach the receiving station with either or both of these waves, depending on the distance between the transmitter and receiver.

d. Skip distance factor. Large transmitting sets using the sky wave as a primary means of communication must consider the characteristics of the skip distance in reaching the desired receiving station. At certain times of day or night, and when the transmitter is operating at certain frequencies, the receiving station may lie within the skip distance area and will not, therefore, receive a signal from the transmitter.

18. FACTORS INVOLVED AT RECEIVER. a. Sensitivity and selectivity of receiving set. The sensi-

tivity is that characteristic which determines to how weak a signal a receiver is capable of responding. The selectivity is the degree to which a receiver is capable of differentiating between the desired signal and signals of other carrier frequencies. A properly aligned and efficiently operated radio receiver has maximum values of selectivity and sensitivity which are determined by the design of the equipment and, in general, cannot be exceeded. The inherent noise level of the receiver circuit is a limiting factor in the sensitivity of a receiving set.

b. Receiving antenna. Erection, location, and electrical characteristics are not as decisive in the operation of the receiving antenna as they are in the transmitting antenna. The receiving antenna must be of sufficient length, however, in some cases must have certain polarization characteristics, and must be properly coupled to the input of the receiver circuit. The condition of the terrain in the vicinity of the antenna may affect the incoming r. f. signal in much the same manner as described in paragraph **17a.**

c. Natural static. This type of static, also known as atmospherics, consists of radio waves generated from such natural sources as thunderstorms, and may travel great distances. Static is present at most frequencies, but diminishes considerably as the frequency is increased. Reception at very high frequencies suffers little from this form of disturbance. Static may be reduced only by the employment of a highly selective receiver and a directional receiving antenna.

d. Man-made static. This type of electrical interference is generated by most types of electrical devices, such as automobile and tank ignition systems, sparking brushes on motors and generators, and other

rotating machines. Whenever an electric spark occurs, a train of radio waves is radiated over a fairly wide band of frequencies. For this reason, man-made static can best be eliminated or minimized at the *source* rather than at the receiver. Cleaning the brushes of a motor or generator, for example, will eliminate this source of interference. Special power-supply filters are used in large installations operating from an a. c. power source. At the receiver, the use of a directional receiving antenna will eliminate some of the man-made static, provided the source of interference is not in the same direction as the transmitting station.

e. Interference from other transmitters on same and adjacent frequencies. The selectivity of a receiver should supply the necessary degree of separation between the desired signal and any desired carrier-frequency signals on adjacent frequencies. However, when the selectivity is not sufficient to exclude signals from closely adjacent frequencies, and when signals from other transmitters on the *same* frequency are being received, the only solution is to change the operating frequency, or arrange a schedule of operation with the interfering transmitters.

f. Capabilities of operator. The skill and technical capabilities of the receiver operator play an important part in obtaining the maximum possible range of operation from the transmitter. The proper erection and location of the antenna and receiving set, control over all tuning, and the resultant control over the sensitivity and selectivity, are all factors directly concerning the radio operator. Maximum sensitivity at the receiver is necessary in order for the transmitter to be operated with the lowest power required for efficient communication.

CHAPTER 3

USE OF RADIO COMMUNICATION

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19. FORMS OF RADIO COMMUNICATION. a. *Radio* is one of the principal means of signal communication within all units of the Army. It is used for tactical control, fire control, administrative purposes, and for liaison between and within all units to which the equipment is available. Radio is used between rapidly moving units where wire or messenger communication is difficult; over large areas where wire or messenger communication is impractical; and between highly mobile elements, such as aircraft and motorized and armored vehicles, where wire or messenger communication is impossible. Radio is especially adapted to rapidly changing situations and, under certain conditions, may be the only means of signal communication available.

b. *Radiotelegraphy* is normally employed between units of higher echelons when the distances involved are great. It may be used by lower units and over shorter distances when, by reason of the subject matter, cryptographed messages are required. International Morse characters are used for radiotelegraphy by the Army and Navy. (See TM 11–459.)

c. *Radiotelephony* is employed within the lower echelons for person-to-person communication when, by reason of the nature of the message or the time factor involved, secrecy is relatively unimportant. It is especially suited for communication between air-

craft, between aircraft and ground stations, between vehicles in motion, between vehicles and ground stations, and between portable, individually carried radio sets. It may be employed in some cases for command and control purposes by commanders of units up to divisions. The use of radiotelephony in combat requires a high degree of training and discipline on the part of the individuals concerned in order to render transmission intelligible, to avoid congestion of the carrier frequency, and to provide the necessary signal security.

20. ADVANTAGES AND LIMITATIONS. Radio communication has only one distinct advantage over other types of signal communication. This advantage is the relatively high degree of mobility of the system, resulting from the fact that no physical circuits are necessary to maintain the related stations. There are, however, a number of important limitations of this advantage of radio communication. The use of radio in the field requires a careful consideration of these limitations:

a. Relatively low traffic-handling capacity.

b. Susceptibility to interference from atmospherics, from enemy communication and jamming station, and from friendly stations.

c. Range of communication is affected by the nature of the terrain.

d. The possibility of the enemy's interspersal of false messages, disguised as communications from friendly stations.

e. Radio offers the enemy a volume of cryptographed messages for study, possibly resulting in an eventual break-down of the code or cipher used.

f. Disclosure through the enemy's position-finding equipment (see FM 11–20) of the approximate number, types, and locations of operating radio transmitters.

g. Disclosure through enemy's *traffic analysis* (see par. 46**d**) of disposition and probable movement of troops. This method of obtaining intelligence by the enemy does not require direction-finding equipment or cryptographic analysis.

21. OVERCOMING LIMITATIONS. The limitations outlined in paragraph 20 can be reduced *in every case* by improving the general technique of the individual radio operator with particular regard to operating procedure, signal intelligence, and signal security.

a. The traffic-handled capacity of a radio net can be increased by a thorough training of operators and the establishment of a proper net operating discipline.

b. Disadvantages resulting from interference can best be overcome by thorough training and experience of operating personnel. Friendly station interference can be minimized by proper care in the assignment of net frequencies. The use of radiotelegraph enables trained and experienced operators to copy through all but the most severe atmospherics. See paragraph 34 for information on methods of copying through enemy jamming.

c. A careful selection of the location of the radio set can minimize the effect of terrain features. Under adverse circumstances, the power of the transmitter may be increased in order to reach a receiving set located in a region having poor ground conductivity.

d. The strict use of a frequently changed *authentication system* will systematically eliminate the enemy's ability to deceive by transmitting false messages.

e. Cryptographic security can be preserved by adherence to the unit Signal Operation Instructions, which provide frequent changes in code and cipher construction.

f. The amount of information revealed to enemy intelligence units by their position-finding equipment and traffic analysis can be minimized by strict observance of signal security during transmission, and by deceptive operation.

(1) Radio operators must be thoroughly familiar with all signal security rules and regulations, and the unit Signal Operation Instructions.

(2) A radio transmitter will use only the minimum amount of power necessary for reliable communication with the station or stations involved.

(3) The use of radio must be kept to a minimum at all times, and limited to communication which is absolutely necessary.

(4) The transmission of call signs will be limited, and the calls will be changed frequently in accordance with the signal operation instructions.

(5) A careful control of the volume and nature of traffic must be maintained.

(6) "Blind," or fake messages may be transmitted by a station to deceive the enemy during certain critical operations, such as troop movements, or preparations for an attack in force.

(7) The location of transmitting sets must be changed frequently to disorganize the enemy's position-finding deductions.

(8) "Dummy" transmitting stations may be established at remote locations further to confuse the enemy's position-finding interferences.

22. TYPES OF RADIO SETS.—The Joint Army-Navy Nomenclature System classifies all radio sets according to the following types:

a. Airborne. A set installed and operated in an aircraft.

b. Air transportable. A set specially designed to be transportable by air, according to specification or military characteristics.

c. Ground, fixed. A large set erected and operated at a permanent location, usually for long-distance communication.

d. Ground, general ground use. A set which can be installed and operated for two or more types of ground use, that is, a set which can be used both as a vehicular ground set and a transportable ground set, or a set which can be used both as a vehicular ground set and a portable pack ground set.

e. Ground, mobile. A set installed as an operating unit in a motor vehicle which has no function other than transporting the radio equipment.

f. Ground, pack or portable. A set capable of being carried by a man (or a horse) and operated, while stationary or in motion, by one person. This class includes those sets commonly known as "walkie-talkie" and "handy-talkie."

g. Shipboard. A set installed and operated from aboard a surface vessel.

h. Ground, vehicular. A set installed in a vehicle which is designed for functions *other* than carrying radio equipment, such as a set installed in a tank or armored car.

i. Ground, transportable. A semiportable set, capable of being transported from place to place, but

requiring a conveyance if moved for any considerable distance.

j. General utility. A set which can be used in two or more of the general type installations: airborne, shipboard, and ground.

23. CLASSIFICATION OF RADIO SETS. a. Type of modulation. A radio set may be classified as being either amplitude-modulated (a-m) or frequency-modulated (f-m).

b. Type of signal. A radio set may be classified as continuous-wave (c-w), tone-modulated, or voice-modulated, according to the kind of signals it transmits or receives. Tone-modulation signals are considered as a form of amplitude modulation. Voice-modulated signals may be either amplitude modulated or frequency modulated.

24. TRAINING OF RADIO OPERATORS. General teaching methods are discussed in TM 11–450. Requirements of radio specialists are contained in AR 615–26. TM 11–459 deals with instruction in the use of International Morse characters. Training in radiotelegraph operating procedure is contained in TM 11–454, and further information concerning combined radiotelegraph procedure is given in FM 24–6, 24–10, and 24–12. Radiotelephone operation procedure is discussed in FM 24–9.

CHAPTER 4

FIELD RADIO STATIONS

SECTION I

LOCATION OF RADIO STATIONS

25. SELECTION OF SITE. The selection of a site for operation of an Army radio station is based on the following:

a. Technical requirements.

b. Cover and concealment.

c. Local communication.

26. TECHNICAL REQUIREMENTS. A radio station should be located in a position that will assure communication with all other stations with which it is to operate. In order to obtain efficiency of transmission and reception, the following factors should be considered:

a. Terrain.

(1) Hills and mountains between stations limit the range of radio sets. When operating in terrain of this nature, select positions relatively high up on the slopes. Avoid locations at the base of a cliff, or in a deep ravine or valley. For operation at frequencies above 20 megacycles, choose whenever possible a location that will give line-of-sight communication.

(2) Dry ground has low conductivity and limits the range of the set. If possible, locate the station near

moist ground which has higher conductivity. Water, particularly salt water, greatly increases the distances that can be covered.

(**3**) Trees with heavy foliage absorb radio waves, and leafy trees have a more adverse effect than evergreens. The antenna should be well clear of all foliage and dense brush to obtain the maximum range.

b. Man-made obstructions.

(**1**) Do not select a position in a tunnel, or beneath an underpass or steel bridge. Transmission and reception under these conditions will be almost impossible, owing to high absorption of the r. f. waves.

(**2**) Buildings between radio stations will hinder transmission and reception. This is particularly true of steel and reinforced concrete types.

(**3**) All types of pole wire lines such as telephone, telegraph, and particularly high-tension power lines should be avoided in selecting a site for the radio set. Such wire lines absorb power from radiating antennas located in close proximity. They also introduce hum and noise interference in receiving antennas.

(**4**) Positions adjacent to heavily traveled roads and highways should be avoided. In addition to the noise and confusion caused by tanks and trucks, ignition systems in these vehicles may cause local electrical interference.

(**5**) Battery charging units and other generators should not be located too close to the radio station.

(**6**) Radio stations should not be located too close to each other.

(**7**) Radio stations should be in quiet localities. The copying of weak signals requires great concentration by the operator, and his attention should not be diverted by extraneous noises.

c. Local command requirements. Radio stations should be located at a sufficient distance from the unit headquarters or command post which they serve to prevent long-range enemy artillery fire or aerial bombardment directed at the stations from striking the command post. Such enemy fire would result from determination of the operating stations' location by hostile position finders. The minimum distance between the command post and the radio stations should be 200 yards.

27. COVER AND CONCEALMENT. Positions should be selected that will provide maximum cover and concealment consistent with good transmission and reception.

a. The open crests of hills and mountains should be avoided. While such a location may permit ideal transmission and reception, the resulting silhouette makes an excellent target for enemy guns. A slightly defiladed position just behind the crest will give better concealment.

b. Many transmitters and receivers can be installed just below the surface of the ground in holes similar to slit trenches, thereby enabling the operator to maintain communications under severe battle conditions. For more permanent battlefield installations, the equipment may be located on a "shelf" just below the surface of the ground in fox holes. This will allow the operator greater freedom of movement. The antenna must extend above the surface of the ground to permit normal communication.

c. All permanent and semipermanent positions should be properly camouflaged for protection against both aerial and ground observation. (See FM 5–20.)

The antenna must be kept free of camouflage material or other obstructions.

28. LOCAL COMMUNICATION. Contact should be maintained between the radio set and the message center at all times either by local messenger or field

Figure 7. Selecting location for a radio station.

telephone. The station should also be readily accessible to the unit commander and his staff.

29. FINAL CONSIDERATIONS. It may often be impossible to satisfy all the desirable conditions for the location of a radio station, and a compromise, depending upon the situation, may have to be made. If radio communication cannot be established in one location, the set should be moved a short distance and another attempt made.

SECTION II

RADIO CALL SIGNS

30. ASSIGNMENT OF CALL SIGNS. All radio stations are identified by call signs. These call signs are allotted by the Chief Signal Officer and are assigned by standing operation instructions to various Army stations in the field. Detailed procedure for assigning radio call signs is contained in FM 11–5.

31. PURPOSE OF CALL SIGNS. Radio communication is established by a call and answer method. A call sign consists of one or more characters used to afford a short and secure means of conveying the identity of stations, commands, and commanders. The various types and uses of radio call signs are discussed in TM 11–454.

SECTION III

INTERFERENCE AND JAMMING

32. RECEPTION THROUGH STATIC AND INTERFERENCE. There are few receiving locations entirely free from either natural or man-made static, and such interference may become extremely troublesome at times. Under these conditions, the following steps should be taken to improve reception:

a. If the receiver is equipped with a crystal filter, this highly selective device can be used to eliminate much of the extraneous noise frequencies on either side of the desired signal.

b. The receiving antenna should be kept in the open and free from contact with tree limbs, shrubs, or other obstructions.

c. If the receiving antenna is provided with an external connection, the length of the antenna should be varied. Increasing or decreasing the length of the antenna may sometimes result in better reception of the desired signal.

d. The volume control of the receiver should be adjusted to the lowest level at which the desired signal can be heard.

e. Headphones should be used in preference to a loudspeaker.

33. JAMMING. a. The transmission of radio signals intended to block out or interfere with radio communication is known as jamming. Deliberate jamming of radio communication by the enemy must be expected, since the enemy wishes to cause disorganization and panic among troops through impairment or disruption of the Army radio communication system.

b. Jamming is more or less effective depending upon the power of the jamming transmitter and the type of interference being radiated. Jamming signals may consist of keyed continuous waves, tone, voice, music, imitation static, or other types of noise signals. The interfering waves may be undamped, amplitude-modulated, frequency-modulated, or a combination of these. The frequency of the jamming transmitter normally can be changed quickly to follow any frequency shifts made in the radio sets being jammed. A number of jamming transmitters may be used simultaneously.

34. REDUCING EFFECTIVENESS OF JAMMING. **a**. Critical military operations should include plans for maintaining communication despite interference created by enemy jamming transmitters. Should enemy jamming necessitate, signal operation instructions should include assignments of widely varying alternate frequencies, if available, with rules for their use.

b. Enemy jamming on one frequency may be discontinued if it is thought that the channel is no longer in use. It is, therefore, a good expedient to maintain "dummy" transmissions on a frequency being jammed, in the hope that the enemy will continue to use jamming equipment on that frequency rather than transfer to some other frequency.

c. Radio operators should be thoroughly trained to cope with jamming interference (par. 35). Operators should be able to copy messages through heavy interference of all types. It has been found that, in general, tone modulation is more readable through jamming than c-w or voice modulation.

35. TRAINING OF OPERATORS. Radio operators must be thoroughly trained to deal with jamming interference whenever it occurs. The effectiveness of jamming can be minimized if the radio operator is trained to—

a. Copy messages through sustained periods of intense static and man-made interference.

b. Use a crystal filter, if one is provided with the receiver.

c. Authenticate all incoming messages (the enemy may intersperse jamming with false messages).

d. Change call signs and shift frequencies promptly, as directed.

e. Eliminate preliminary calling, requests for reports on signal strength, and other routine messages which are not indispensable.

f. Guard against the possibility of panic at the first indications of jamming. Expect enemy jamming and have the determination to get the message through under any condition.

SECTION IV

OPERATING REGULATIONS

36. GENERAL. a. Radio operating procedure is discussed in TM 11–454, FM 24–6, FM 24–9, FM 24–10, FM 24–11, and FM 24–12. (See par. 2.) All operating procedure and regulations are to be in accordance with these manuals. Deviation from authorized procedure usually results in delaying traffic and is strictly forbidden.

b. Radio stations will transmit only those messages authorized by competent authority. All transmissions

and messages will be regarded as official communications.

c. Radio stations will be supplied with telephone communication whenever practicable, and especially when the station is remote from the command post.

d. Close cooperation with the message center is essential.

e. No superfluous calls or signals of any kind will be transmitted, and the unauthorized use of plain language is prohibited.

f. Radio operators will be instructed in maintaining communication security. (See sec. V.)

37. METHOD OF SETTING STATIONS ON FREQUENCY. a. General. A frequency standard is any device capable of generating a signal of known frequency, and/or receiving a signal and accurately measuring its frequency. To set either the receiver or the transmitter frequency on the frequency of a standard, a process known as *zero beating* is used. (If the transmitter is crystal-controlled, merely select the proper crystal and check the frequency with the frequency standard.)

b. Zero beating receiver to frequency standard.
(**1**) Turn on receiver and frequency standard, and allow sets to warm up (for 15 minutes if possible).
(**2**) Set frequency standard on assigned frequency. (Do not move frequency standard dial after it has been correctly set.)
(**3**) Turn on receiver beat-frequency oscillator.
(**4**) By reference to receiver calibration chart, or to receiver dial if it is directly calibrated in frequency, set receiver dial on approximately the assigned frequency.

(5) While listening in receiver headset, rotate receiver tuning dial until signal from frequency standard is heard as a high-pitched whistle.

(6) Continue rotation of receiver dial until whistle drops to a very low note, or disappears entirely, and then begins to rise in pitch. Reverse the direction of rotation until whistle again drops to the lowest pitch or disappears. If there is broad tuning at zero beat; that is, if the receiver can be tuned over a small range on the dial before the whistle reappears, care should be taken to place receiver dial midway between the setting at which the whistle disappears and that at which it reappears. Just before reaching zero beat, switch frequency standard off and on to make certain that the signal is the one emitted by the frequency standard. The whistle should disappear and reappear.

(7) The receiver is now on the same frequency as the frequency standard and is said to be in zero beat with it.

(8) For reception of voice or tone transmissions, turn off the beat-frequency oscillator of the receiver.

(9) For c-w reception, adjust the beat-frequency oscillator control until a pleasing note is heard. If the receiver has no beat-frequency oscillator control, turn the receiver dial slightly to the *high-frequency* side of the zero-beat setting and adjust for a pleasing note.

(10) If some stations in the net are not heard at the setting, they may be slightly off frequency. Locate them by tuning slightly to each side of the correct frequency.

c. Zero beating transmitter to frequency standard.

(1) Turn on frequency standard, and allow set to warm up (for 15 minutes is possible).

(2) Listen on the assigned frequency. If other sta-

tions are working, wait until they are through in order to avoid causing interference.

(**3**) If transmitter is equipped with side-tone feature, take the necessary steps to render this device inoperative during the adjustment period. In many Army sets this can be accomplished by making the initial zero-beat adjustment in the voice position.

(**4**) Turn on transmitter and allow tubes to warm up.

(**5**) Set frequency standard on assigned frequency by referring to the calibration chart. (Do not move frequency standard dial after it has been correctly set.)

(**6**) By reference to transmitter calibration chart, tune the transmitter to approximately the assigned frequency.

(**7**) Close the transmitter key (send long dashes—do not hold key down). While listening in headset of frequency standard, slowly rotate the transmitter tuning dial until high-pitched whistling notes are heard. These notes should correspond to the keying of the transmitter.

(**8**) Continue rotation of transmitter dial until the whistling drops to a very low note, or disappears entirely, and then begins to rise in pitch. Reverse the direction of rotation until whistling again drops to its lowest pitch or disappears. If there is broad tuning at zero beat, that is, if the transmitter dial can be rotated a short distance after whistling disappears before it reappears, care should be taken to set the transmitter dial midway between points where the whistling disappears and reappears.

(**9**) If adjustment is made with switch in voice position and c-w operation is desired, turn the switch to c-w position and make final zero beat adjustment.

(**10**) The transmitter is now on the same frequency as the frequency standard and is said to be in zero

beat with it. The tuning dial should be locked at this setting, if a dial lock is provided.

38. USING FREQUENCY METER SET SCR-211-(*) AS FREQUENCY STANDARD. a. Preparation of SCR-211-(*).

(**1**) Turn on frequency meter and allow set to warm up (15 minutes if possible).

(**2**) Set frequency meter to assigned frequency.

(**3**) Connect a short antenna (2 to 3 feet) to the antenna binding post. Do not connect antenna terminal directly to any part of the receiver or transmitter being adjusted.

b. Adjustment of receiver.

(**1**) Turn on receiver and allow to warm up.

(**2**) Set the receiver dial on approximate assigned frequency.

(**3**) Turn on beat-frequency oscillator.

(**4**) Zero bear receiver to the frequency meter.

(**5**) Adjust receiver for type of reception desired (voice, tone, c-w).

c. Adjustment of transmitter.

(**1**) Turn on transmitter and allow to warm up.

(**2**) Set transmitter tuning dial(s) to approximate assigned frequency.

(**3**) Zero beat transmitter to frequency of SCR-211-(*).

(**4**) Lock transmitter tuning dial(s) at zero-beat setting.

Note. The symbol (*) is used in place of the suffix letters in equipment titles to designate all models of a series.

39. NET CONTROL STATION AS FREQUENCY STANDARD. When no SCR-211-(*) or equivalent is available, another station in the same net (preferably

the net control station) should be used as the frequency standard. The station should be identified by call letters and authentication.

a. Adjustment of receiver.

(**1**) Turn on receiver and allow it to warm up.

(**2**) Tune receiver to approximate assigned frequency.

(**3**) Tune in net control station (or other station to be used as standard) and zero beat to the received signal.

(**4**) Do not change the frequency setting of the receiver after zero beat is obtained. The receiver will be used as a frequency standard for the transmitter. Hence, it must be left at the setting of zero beat with the net control station.

b. Adjustment of transmitter.

(**1**) Turn on transmitter and allow to warm up.

(**2**) Set tuning dial(s) on approximate assigned frequency.

(**3**) Zero beat transmitter to receiver.

(**4**) Lock transmitter tuning dial(s) at zero-beat setting.

c. Procedure when receiver has no beat oscillator (voice or tone operation only).

(**1**) Tune in frequency standard signal, adjusting receiver tuning until signal is received at maximum strength.

(**2**) Reduce receiver gain control to a low setting.

(**3**) Adjust transmitter to approximate assigned frequency.

(**4**) Turn on transmitter and allow it to warm up.

(**5**) While speaking into the microphone in a low tone of voice (or with the tone oscillator turned on), rotate the transmitter tuning dial until voice or tone is heard in receiver headset at maximum volume and clarity.

(6) If the transmitter is known to be on correct frequency, the above procedure can be followed, but the receiver should be tuned to the transmitter, rather than the transmitter to the receiver.

40. NO FREQUENCY STANDARD AVAILABLE.

a. An approximate adjustment may be made by selecting the receiver or transmitter as a standard. If the transmitter is crystal-controlled, it should be chosen as the frequency standard. If the transmitter is of the master-oscillator power-amplifier type of circuit, the receiver may be more accurately calibrated. Past operating experience should make it possible to determine which unit to use.

b. Within the continental United States, receiver calibration may be checked by tuning to either of two standard frequencies transmitted from station WWV (5000 and 15000 kilocycles). Outside the continental United States, any station of known frequency, within range of the receiver, may be used for checking purposes. After selecting one unit as a standard, zero beat the other unit to it.

41. SUMMARY OF FREQUENCY CALIBRATION.

a. Listen on a selected frequency before making any transmitter adjustments, so that unnecessary interference with friendly stations may be avoided.

b. In zero beating a transmitter to another unit, care must be taken to keep the transmitter on the air for as short a time as possible. The purpose of this precaution is to avoid unnecessary interference with friendly stations, and to provide the enemy with the least possible chance for locating the position of the radio station by means of direction-finding equipment.

c. "Dummy" antennas, when available, should be used for all transmitter tuning adjustments.

42. TRANSPORTATION OF FIELD RADIO EQUIPMENT. Radio equipment is comparatively delicate and its serviceability is governed to a great extent by the care with which it is packed for transportation. Operating equipment will be packed and loaded in such a manner as to protect it from dust and dirt, weather, shocks of the road, and injury from other articles loaded in the same vehicle.

SECTION V

COMMUNICATION SECURITY

43. GENERAL. a. Communication security is the safeguarding of friendly radio communication against the availability and intelligibility of such communications to hostile persons or agencies.

b. The radio transmitter is a prolific source of intelligence to the enemy in field operations. Every radio transmission, regardless of its nature, offers information to an alert enemy. Further, radio operators have equipment and documents in their possession which are extremely valuable to the enemy. It is necessary, therefore, that all radio operators have a comprehensive understanding of general communication security (FM 11–35) and radio communication security (TM 11–454).

c. Radio security is the responsibility of all personnel concerned with radio communication. It consists not only of guarding what is transmitted, but of limiting the use of radio to necessary transmissions.

d. Communication security consists of three principal components, namely:
(**1**) Physical security.
(**2**) Cryptographic security.
(**3**) Transmission security.

44. PHYSICAL SECURITY. a. This security consists of the protection of communication equipment, messages, cryptographic systems, and documents from capture, theft, loss, or inspection by unauthorized persons or agencies. This physical protection is the responsibility of all radio communication personnel. The procedure for handling classified material is specified in AR 380–5.

b. Field radio operators must be alert at all times to safeguard signal communication equipment and material from seizure by the enemy. Orders for the destruction of equipment (par. 49) will be carried out promptly and thoroughly. The loss or compromise of communication material will be reported immediately.

45. CRYPTOGRAPHIC SECURITY. Messages will not be sent in the clear unless specifically authorized by higher authority. Message center personnel are primarily concerned with the ciphering and deciphering of messages, but radio operators must observe all the rules of cryptographic systems in use.

46. TRANSMISSION SECURITY. a. General. This security concerns the prevention of enemy interception of radio communications, and the minimizing of information which may be obtained by the enemy from such communications by means other than cryptanalysis. The radio operator is primarily concerned

with this type of communication security. (See TM 11-454.)

b. Interception. All messages transmitted by radio are susceptible to interception by hostile receivers. Using the minimum power necessary to maintain communication will limit enemy interception, and will also lessen interference with friendly stations. In some cases, the sky waves (pars. 10 and 11) may travel several hundred miles into enemy territory. The strength of signals reflected back to earth at such distant points can be limited by a reduction in power at the transmitter.

c. Direction finding. Any radio transmitter can be located by enemy direction-finding stations, which are effective on nearly all frequencies. Since these hostile stations are less likely to obtain accurate bearings on short transmissions, periods of operation in the field should be as brief as possible.

d. Traffic analysis.

(**1**) Although all messages may be cryptographed, a systematic analysis of intercepted radio traffic may provide the enemy with much useful information. This traffic analysis is based upon—

(**a**) Amount of traffic and length of messages.

(**b**) Call signs.

(**c**) Routing and relay instructions.

(**d**) Precedence (priorities).

(**e**) Procedure signs and operating signals.

(**f**) Times of origin and receipt.

(**2**) The enemy will quickly perceive that certain military actions will result from the transmission of certain types of radio messages.

e. Security measures. Transmission security to combat traffic analysis and all other enemy intelligence

activities is based on the following defensive measures:
(**1**) Minimum use of field radio sets.
(**2**) Use of minimum power necessary to maintain communication.
(**3**) Strict compliance with radio silence restrictions.
(**4**) Eliminating unnecessary and unauthorized transmissions (such as informal conversations).
(**5**) Use of authorized procedures only.
(**6**) Correct use of radio call signs.
(**7**) Elimination of superfluous routing instructions in message headings.
(**8**) Strict control of routine test transmissions in order that their timing and volume will give no advance information of impending operations.
(**9**) Transmitting all messages at the copying speed of the slowest operator in the net to avoid repeating messages or message groups.
(**10**) Authenticating messages.
(**11**) Tuning of transmitters with dummy antennas, or with the normal antennas disconnected, if possible.
(**12**) Maintaining correct frequency assignments.
(**13**) Using broadcast and intercept methods. (See TM 11–454.)
(**14**) Frequent changing of station locations.
(**15**) Maintaining radio watches on designated frequencies and at prescribed times.
(**16**) Avoiding the development of any characteristic keying habits or personal phrases by a particular radio operator.

47. VOICE TRANSMISSION SECURITY. In radiotelephone conversations, all personnel concerned must avoid revealing information by the careless mention of places, names of units or personnel, etc. Wording of

voice transmission should be premeditated. Names of units are not to be mentioned in clear, either in the heading or text of a radiotelephone message.

48. DISCREPANCY REPORTS. a. Friendly radio stations should be monitored by radio intelligence units to insure that transmission security rules are not violated, and that proper radio procedure is being used. Discrepancies noted should be reported to the signal or communication officer concerned for appropriate action. Such a report contains the following information relative to the observed station(s):

(**1**) Call sign(s).
(**2**) Frequency.
(**3**) Date of transmission.
(**4**) Time of transmission.
(**5**) Actual transmission(s).
(**6**) Specific reference to the paragraph of authoritative document which has been violated.

b. The primary purpose of discrepancy reports is to improve radio communications by educating the operators concerned. If, however, it is obvious that a violation is intentional or due to carelessness, disciplinary action should be taken.

SECTION VI

DESTRUCTION OF EQUIPMENT

49. PURPOSE OF DESTRUCTION. Personnel concerned with the operation of radio equipment should be thoroughly prepared to destroy such equipment when ordered by a higher headquarters, or when in im-

mediate danger of capture by the enemy. Complete destruction of the equipment will deny the enemy the use of it or any parts thereof, as well as any information concerning its design. Prescribed methods for equipment destruction are included in Technical Manuals and other publications. In general, the instructions contained in paragraphs 50 and 51 will apply.

50. PRIORITY OF DESTRUCTION. Certain parts of radio equipment must be destroyed to an extent sufficient to prevent their future use or reclamation. The particular importance of these parts requires the prescription of the following scale of priorities:

a. Parts which are nonstandard and unusual in design, from either a mechanical or an electrical standpoint. There is little likelihood that the enemy can replace such specialized parts, particularly if all captured units of a given item have the same nonstandard component destroyed.

b. Critical units. The enemy is less likely to be able to replace these than noncritical units.

c. Parts interchangeable with other equipment. These units are destroyed or damaged to prevent the enemy from using them to salvage other types of destroyed equipment.

d. All other parts.

51. GENERAL METHODS OF DESTRUCTION.
a. Radio sets.

(1) Shear off all panel knobs, dials, switches, etc., with an axhead. Break open the compartment by smashing in the panel face. Then knock off the top, bottom, and sides of the compartment. The object is to destroy the panel and expose the chassis.

(2) Using the axhead, smash all tubes and circuit elements on top of the chassis.

(3) On the underside of the chassis, the axhead is used for shearing and tearing off wires and small circuit units. Socket bases should be broken, and circuit elements and wiring cut.

(4) Tubes, coils, crystals and holders, microphones, earphones, loudspeakers, and batteries should be smashed and destroyed in the same general manner. Make certain that all variable capacitors are thoroughly demolished, since the enemy finds these most difficult to replace.

(5) If time permits, pile up the equipment already smashed, together with any inflammable materials that are available, such as wood, sawdust, straw, cloth, etc. Pour on liberal quantities of either gasoline or oil, and set on fire.

(6) Smashed parts which cannot be destroyed by fire should be buried in the earth or in stream beds, if possible.

b. Radio stations.

(1) The general destruction of radio stations is accomplished in much the same manner as described for radio sets, except that additional demolition is required for all permanent fixtures, such as antenna towers and power plants.

(2) Large, permanent, or heavy fixtures may be destroyed by explosives.

(3) Engines, generators, and power switchboards may be demolished by the methods already covered.

CHAPTER 5

CONTROL AND SUPERVISION OF RADIO ACTIVITIES

52. CLASSIFICATION OF ACTIVITIES. Radio activities within the theater of operations are classified as being either military or civil.

a. Military activities include the strategic, tactical, and administrative use of radio communication, the collection of signal intelligence, the location of air and sea targets by radar, and radio aids to navigation.

b. Civil radio activities, both private and commercial, are discussed in FM 11–5.

53. MILITARY RADIO COMMUNICATION ACTIVITIES. a. Strategic.

(1) Control of strategic ground forces.
(2) Control and direction of strategic air operations.
(3) Communication, by means of the War Department net, between zone of interior and theaters of operations.
(4) Long-range air reconnaissance.
(5) Other strategic operations.

b. Tactical.

(1) Control of tactical ground forces.
(2) Control and direction of tactical air operations.
(3) Close-range air reconnaissance.
(4) Ground reconnaissance.
(5) Other tactical operations.

c. Administrative.

(**1**) Communication by means of the War Department administrative net.

(**2**) Army Airways Communication System.

d. Other types.

(**1**) Transmission of standard frequency signals.

(**2**) Transmission of standard time signals.

(**3**) Broadcasting.

(**a**) Propaganda.

(**b**) Entertainment for friendly troops.

54. OTHER MILITARY ACTIVITIES. a. Radio intelligence activities, which are concerned primarily with the collection of signal intelligence rather than with signal communication, are discussed in FM 11–35 and FM 11–20. Radio security practices are established in Standing Operating Procedures and published in Signal Operation Instructions.

b. The location of friendly and hostile aircraft and surface vessels by means of radar is a function of the Aircraft Warning Service (FM 11–25) in coordination with other Government agencies.

c. Radio aids to navigation are maintained and operated by the Army Air Forces.

55. CONTROL AND SUPERVISION OF ACTIVITIES. The signal system in an infantry division normally will include from 50 to 60 radio nets; an armored division may use from 100 to 130 nets. Thus, in a theater of operations in which several divisions are engaged, the total number of radio nets is very large. The operation of a system of such broad scope requires a high order of supervision and control to prevent interference among radio units. The following steps are taken to attain this supervision and control:

a. The assignment of call signs to all radio stations in the theater of operations.

b. The assignment, as effectively as possible, of non-interfering frequencies to the various nets. If necessary, certain nets may be silenced when others on the same frequency have more important traffic to transmit.

c. The close supervision of all net operations to insure the observance of orders and regulations contained in the Signal Operation Instructions and the Standing Operating Procedures. (See FM 11–20).

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